# 3.0 ECONOMIC ANALYSIS

Cost data were compiled during the SITE demonstration at the Minergy facility in Winneconne, Wisconsin, as well as from information obtained from Minergy. Costs have been placed in 12 categories applicable to typical clean-up activities at Superfund and RCRA sites Evans 1990). Costs are considered to be order-of-magnitude estimates, with an expected accuracy to within 50 percent above and 30 percent below actual costs.

This section describes costs associated with using GFT to treat contaminated sediment and presents the conclusions of the economic analysis.

## 3.1 INTRODUCTION TO ECONOMIC ANALYSIS

PCBs are identified in river and stream sediments at various locations throughout the United States. Various remedial options are under consideration for treating these and other contaminated sediment. This economic analysis presents costs associated with vitrifying contaminated river sediment at high temperatures, removing, destroying, or binding PCBs and any metals in the glass aggregate product produced. Several cost scenarios were reviewed, including varying the size and annual operational days for the system. The scenario used for this analysis consisted of one sediment melter rated at about 600 tons of sediment per day combined with three dryers rated at an input capacity of 200 dredged-and-dewatered tons per day per dryer. Sediment storage was included to allow year-long operation in all climates.

Important assumptions regarding operating conditions and task responsibilities that could affect the cost estimate results are presented in the following sections.

## 3.2 BASIS OF ECONOMIC ANALYSIS

Costs for the GFT have not previously been applied to full-scale remediation projects for sediments. Historical project construction data and data for relatively standard construction practices are available for other components, such as sediment removal and disposal, but such data are not available for the GFT.

A conventional present worth (PW) approach was used for this cost analysis. This approach is universal, in that it provides procedures for computing the PW of any cost to be considered. In the conventional approach, each cost is escalated and discounted in separate steps, as necessary to determine its PW.

Costs incurred over the lifetime of a project are classified into four types of cost with respect to frequency of occurrence:

1. One-time costs are incurred only once over the life of the project. These costs include those for initial investment, startup, and some alterations or modifications.
2. Continuous costs are incurred periodically throughout a given year. Examples are energy costs, operational labor costs, scheduled maintenance costs, and sampling costs.
3. Cyclical costs are incurred several times over the life of the project, but less than annual costs. Some of these costs include some alterations, repair, or replacement of equipment.
4. Annually recurring costs are incurred once each year over the life of the project. These costs would include annual monitoring and permitting.

The cost elements in the following section were classified into one of these four categories. The cost of all items was assumed to escalate at a rate less than, or equal to, the general inflation rate. Therefore, the differential escalation rate is zero. The discount rate, based on the Office of Management and Budget (OMB) Circular A-94 and a project life expectancy of 15 years, was calculated at 3.3 percent (OMB 1972). Several additional assumptions were made in this cost estimate, based on an understanding of process requirements, equipment design, and information from the demonstration project performed. Assumptions are identified as they relate to each section of the process.

## 3.3 COST ELEMENTS

The costs directly attributable to the treatment component are discussed below in terms of the cost elements generally used by the SITE Program for evaluating treatment costs based on field tests for treatment technologies. The relative importance of each element in selecting various treatment technologies depends on unit operations involved in the process, the importance of chemical additives for the process, energy requirements and costs, and project-specific factors. The cost elements are the following:

- **Site Preparation Costs -** This element includes site design and layout, surveys and site logistics, legal searches, access rights and roads, preparation of support facilities, and utility connections. Where the site is used for more than just the treatment technology (for example, pretreatment or disposal of residues), site preparation costs may be partially included in the costs for other components.

- **Permitting and Regulatory Requirements -** This element includes permits required by RCRA, TSCA, and CAA, system monitoring requirements as may be required by state regulations, and development of monitoring and analytical protocols to comply with regulatory requirements.

- **Capital Equipment -** Major equipment items, process equipment, and residual materials handling equipment are included in this element. The annualized equipment cost is based on the life of the equipment, the salvage value, and the annual interest rate.

- **Startup Costs -** Costs associated with operator training, system startup, and ensuring the proper functioning of the system.

- **Labor Costs -** Labor charges for operational, supervisory, administrative, professional, technical, maintenance, and clerical personnel supporting the treatment processes must be estimated for this element.

- **Consumables and Supplies -** The raw materials and supplies required to process the material are included in this element.

- **Utilities -** Fuel, oxygen, and electricity required to process the material are included in this element.

- **Residue Treatment and Disposal Costs -** Treatment systems may generate one or more residues (for example, water, oil, solids, sludges, air, or gas) that require further treatment before discharge or disposal. This element may also include filters or carbon treatment to control air emissions.

- **Transportation Costs -** Some transportation of dewatered sediment may be necessary if the treatment facility is not located in proximity to dredging and dewatering operations. Costs do not include transportation of glass aggregate to an off-site location.

- **Monitoring and Analytical Costs -** Field and laboratory costs for monitoring conditions of the treatment process and the quality of residues are included in this element.

- **Facility Modification, Repair, and Replacement Costs -** This element includes design adjustments, facility modifications, scheduled maintenance, and equipment replacement. Maintenance labor costs are assumed to be part of the operational labor costs.

- **Site Demobilization Costs -** Costs for demobilizing the GFT include equipment demolition and general clean-up.

The 12 cost factors examined as they apply to GFT, along with the assumptions employed, are described in the following paragraphs and are shown in Table 3-2.

### 3.3.1 Site Preparation

The amount of preliminary site preparation required will depend on the site’s location, suitability for development, and proximity to dredging operations. Site preparation components include site design and layout, surveys and site logistics, legal searches, access rights and roads, preparation for support and decontamination facilities, utility connections, fixed auxiliary buildings, and soil stockpiling. No costs for geotechnical evaluation of the treatment site are included. It is also assumed that the facility will be constructed in an area zoned industrial. Because of the variability in property value and utility availability throughout the country, costs associated with lease or purchase of property are not included. This cost analysis begins with the sediment dewatered to a moisture content of 50 percent; therefore, excavation or dredging, mobilization, and dewatering costs are not included. It is assumed that metals removal during full-scale implementation will occur prior to dewatering; additional metals removal is not included as part of this cost estimate.

Once dewatered, the material will be moved by front-end loader to the drying equipment. Costs to move the material to the treatment unit include costs for operating heavy equipment, labor charges, and equipment fuel costs. These costs are broken down in the labor, capital equipments and consumables sections; therefore, no site preparation costs are included in this cost analysis.

### 3.3.2 Permitting and Regulatory Costs

Permitting and regulatory costs will vary, depending on location of the treatment facility. ARARs include federal standards, as well as more stringent standards under state or local jurisdiction.

All of the exhaust cooling systems in the GFT use non-contact heat exchangers to prevent contamination of cooling water. The exhaust is designed to allow for minimal particulate within the air stream. Costs for initial permitting of this facility are estimated at about $150,000. Sampling of the air stream and wastewater for permitting purposes is estimated to be $10,000 per year, which includes professional services, analytical services, and regulatory fees. Initial permitting is a one-time cost, and sampling and permit update costs are an annually recurring cost. Using a discount rate of 3.3 percent, the net PW of the permitting and regulatory costs is $252,400. Based on the estimated project life of 15 years and facility throughput of 210,000 tons per year, the permitting and regulatory cost is estimated to be $0.08 per ton.

### 3.3.3 Capital Equipment

Equipment costs associated with the GFT include the sediment storage building, melter building, sediment mixers, sediment dryer, sediment-handling system, glass melter, oxygen-generating plant, and off-gas treatment system. Capital costs are based on information supplied by Minergy. Costs to construct the melter, associated equipment, and buildings, as detailed in Table 3.1, are estimated at $36,387,736. Based on an estimated operating life of 15 years and contaminated sediment volume of 210,000 tons per year, the estimated capital equipment cost is $11.55 per ton.

**TABLE 3-1**
**PROJECTED CAPITAL COSTS - SEDIMENT MELTING PLANT**

| Item | Cost | |
|---|---|---|
| Melter (delivered and installed) | $ | 7,511,976.00 |
| Dryer (3@ $862,835) | $ | 2,588,505.00 |
| Materials-Handling System | $ | 3,019,923.00 |
| Dryer Off-gas System | $ | 394,515.00 |
| Thermal Oil System | $ | 995,579.00 |
| Air Quality Control System | $ | 468,931.00 |
| Oxy-fuel System | $ | 845,081.00 |
| Utilities Equipment | $ | 488,383.00 |
| Mechanical Contractor | $ | 7,886,711.00 |
| Electrical Contractor | $ | 2,113,548.00 |
| Main Building | $ | 2,634,900.00 |
| Engineering | $ | 5,274,684.00 |
| Front-end loader | $ | 365,000.00 |
| Sediment Storage Building | $ | 1,800,000.00 |
| **TOTAL** | **$** | **36,387,736.00** |

### 3.3.4 Startup Costs

Startup costs include training of operators and workers on equipment use and health and safety procedures, initial system testing, and system shakedown. Startup costs are estimated at $764,000. Based on an estimated operating life of 15 years and contaminated sediment volume of 210,000 tons per year, the estimated capital equipment cost is $0.24 per ton.

### 3.3.5 Labor Costs

The facility is assumed to operate 24 hours per day, 350 days per year. Based on operations at similar facilities and observations during the SITE demonstration, a four-person crew per shift should be adequate for safe operation of the facility. The crew would consist of a shift supervisor, two equipment operators, and a laborer. Assuming three shifts consisting of four crews, labor charges for operational, supervisory, administrative, professional, technical, maintenance, and clerical personnel supporting the treatment processes are estimated at $2,382,000 per year. The net PW of labor costs over the 15-year life is estimated at $27,829,000. Based on the throughput of 210,000 tons per year, estimated labor costs are $8.83 per ton.

### 3.3.6 Consumables and Supplies

Minergy has estimated the consumables and supplies to cost $241,900 per year. In addition, the system uses a lime flux rate of approximately 15 percent. With a lime flux cost of $25 per ton, flux costs are estimated at $447,000 per year. The net present worth of consumables and supplies over the 15-year life is estimated at $8,048,400. Based on the throughput of 210,000 tons per year, estimated consumables costs are $2.56 per ton.

### 3.3.7 Utilities

The facility is expected to use approximately 1.9 million Btu of gas per ton of treated sediment and 115 kilowatt-hours of electricity per ton of treated sediment. Based on estimates of gas delivery at $3.25/million btu and an electricity rate of 4.5 cents per kilowatt hour, utility costs are estimated at $2,403,000 per year. The PW of operational costs over the 15-year life is estimated at $28,074,000, or $8.91 per ton.

### 3.3.8 Residue Treatment and Disposal Costs

The three sources of process water for the operation are condensate from the dryer, blowdown from the packed tower on the melter exhaust, and cooling tower blowdown. The condensate from the dryer may have high total suspended solids (TSS), as well as potential PCB contamination, attached to sediment particles. This water will require treatment prior to disposal. The packed tower blowdown will have high concentrations of TSS and high chemical oxygen demand. The cooling water blowdown is a non-contact cooling water and therefore would not require treatment prior to disposal.

The volume of process water requiring treatment is estimated at 63 gallons per minute, for an annual estimated volume of 31.7 million gallons. This process water will be routed through the wastewater treatment facility processing the dredged sediment. If the sediment is delivered to the melter in a dewatered state, no treatment facility for the dredged water will be available. Therefore, it is assumed that this water would be sent to a municipal treatment facility. Assuming a municipal charge of $1.50 per 1,000 gallons, the annual costs for treating the process water is estimated to be $47,600, or over the life of the facility, an estimated cost of $0.18 per ton.

### 3.3.9 Transportation Costs

It is assumed that for the full-scale operation of the GFT, the facility will be located next to the dewatering operation and that no transportation of the dewatered sediment will be necessary before staging the sediment for processing through the GFT.

### 3.3.10 Monitoring and Analytical Costs

Field and laboratory costs for monitoring conditions of the treatment process and the quality of residues are included in this element. Incoming sediment will be sampled at a rate of one sample per 300 tons of sediment. Treated material will require initial analysis to prove treatment effectiveness and periodically throughout the treatment process. Monitoring and analytical costs are estimated at $300,000 per year. Based on the 15-year life and throughput of 210,000 tons per year, estimated monitoring and analytical costs are $1.11 per ton. These monitoring and analytical costs are based on TSCA regulatory requirements as the most stringent requirements. In some cases less stringent monitoring may be possible.

### 3.3.11 Facility Modification, Repair, and Replacement Costs

Maintenance labor is included as a part of operational labor costs. Minergy has estimated operations, replacement, and repair costs to be $1,370,455 per year. Modification costs are site-specific and vary, based on weather issues, regulatory changes, or operational observations; therefore, modification costs are not included in this cost estimate. Based on the 15-year life and throughput of 210,000 tons per year, estimated operations and maintenance costs are $5.08 per ton.

### 3.3.12 Site Demobilization Costs

It is assumed that the site used for the treatment process will be purchased or leased by Minergy or the responsible party. Site restoration requirements will vary, depending on the future use of the site, and therefore are not included in this analysis. Costs to demobilize equipment at the end of 15 years are estimated at $1,000,000. Based on the above-identified discount rates and sediment throughputs, the estimated cost for demobilization of the equipment is estimated at $0.20 per ton. Based on the above costs, the total cost to treat dredged-and-dewatered sediment with the GFT was estimated at $38.74 per ton.

## 3.4 BENEFICIAL REUSE

The GFT glass aggregate product passes the ASTM water leachate test. Contaminants contained in the river sediment appear to be stabilized within the glass matrix of the product and, according to data obtained during the SITE demonstration, are not available to leach into the environment. Leaching tests were conducted to evaluate the primary objective associated with beneficial reuse of the glass aggregate, the methods for which are discussed in Section 4.3.2.7. Results of the leaching tests and a comparison to beneficial reuse criteria is presented in Section 4.3.3.1. Further, the GFT glass aggregate product can be stored like any quarried aggregate.

Glass aggregate product can meet industrial requirements for the manufacture of the following products:

- Ceramic floor tile
- Abrasives
- Concrete additives
- Asphalt paving and chip seal
- Roofing shingle granules

Depending on use, markets may require additional manipulation of material, and those costs are not included in this analysis. Glass aggregate product sales will vary by demand, and credits are also not included as part of this cost analysis.

## 3.5 SUMMARY OF ECONOMIC ANALYSIS

This section summarizes the costs for the GFT process. Costs were based on information from the pilot study, data supplied by Minergy, and information collected from other industry sources. Estimated costs identified within this section were based on the assumptions previously identified in Sections 3.2 and 3.3. The facility identified within this section is estimated to treat about 600 tons of dredged-and-dewatered sediment per day, which produces about 250 tons of glass per day. It is estimated that the facility would operate 350 days per year for 15 years, which works out to approximately 3.2 million tons of treated sediment.

The net present value (NPV) of the facility was determined for all components. To compute NPV, it is necessary to discount future benefits and costs, which reflect the time value of money. The discount rate used for this estimate was 3.3 percent, based on current OMB guidelines.

The NPV of the facility described in this document was estimated at $122,041,000. The estimated cost per ton to treat the sediments is $38.74 per ton.

Costs identified in Section 3.3 are summarized in Table 3-2.

**TABLE 3-2**
**SUMMARY OF COSTS FOR MINERGY GLASS FURNACE TECHNOLOGY**

| Cost Element | Estimated Cost per Ton | Percent of Total |
|---|---|---|
| Site Material Preparation Costs | - | - |
| Permitting and Regulatory Costs | $ 0.08 | 0.2 |
| Capital Equipment | $ 11.55 | 29.8 |
| Start-up Costs | $ 0.24 | 0.6 |
| Labor Costs | $ 8.83 | 22.8 |
| Consumables and Supplies | $ 2.56 | 6.6 |
| Utilities | $ 8.91 | 23.0 |
| Residue Treatment and Disposal | $ 0.18 | 0.5 |
| Transportation | - | - |
| Monitoring and Analytical | $ 1.11 | 2.9 |
| Facility Modification, Repair, and Replacement | $ 5.08 | 13.1 |
| Site Demobilization and Restoration | $ 0.20 | 0.5 |
| **TOTAL** | **$ 38.74** | **100** |